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Risk aversion connectedness in five European countries

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ABSTRACT

In this paper we compute an aggregate index of risk aversion and indices of vulnerability and the contribution to systemic risk aversion for five European countries. The variance risk premium proxies risk aversion. The contribution to the literature is twofold. First, this is the first study estimating not only the common component, but also indices of directional connectedness among variance risk premia. Second, it is the first to estimate the interconnections by means of a FIVAR model, in order to account for long memory. Our analysis indicates measures of total and directional connectedness unlike those that would be obtained with the use of a short memory VAR. These differences arise when the focus is on market turmoil periods and on forecast horizons of thirty days. Future research evaluating spillovers among long memory series can benefit from our results. Policy-makers should take these interconnections into account when adopting effective macroeconomic policies.

1. Introduction

In this paper we construct indices of total and directional connectedness in risk aversion in relation to five European stock markets: the UK, Germany, Switzerland, France and the Netherlands, in the period 2000–2013. The choice of the countries under investigation reflects the decision to include both EMU and non-EMU countries and is based on the availability of a variance index traded in each country (the only country excluded is Belgium since its market volatility index VBEL was traded only for a limited period and it is not traded at present). The choice of the sample period allows us to identify several periods of uncertainty in the European market, ranging from the corporate scandals (such as Vivendi in France) in the first part of our data-set to the Lehman Brothers collapse and the recent European sovereign debt crisis. Moreover, by considering EMU and non-EMU countries, we can identify whether spillovers of risk aversion are determined by different monetary policies implemented in these different countries.

As a measure of risk aversion, we focus on the variance risk premium since it shows how much an investor is willing to pay to hedge against increases in variance. Our choice is motivated by the studies of Bollerslev et al. (2009) and Bekaert and Hoerova (2014) indicating that the variance risk premium is a robust predictor of excess stock returns. Moreover, Bekaert and Hoerova (2016), using a dynamic asset price model, find that the variance risk premium is highly informative about risk aversion in the US and Germany. Technically, the variance risk premium is computed as the difference between the risk-neutral expectation and the physical expectation of the returns variance. The risk-neutral expectation can be obtained from option prices listed on the underlying asset, and in this study it is assumed to be equal to the square of the volatility index. The physical expectation can be either obtained as a forecast from the past or proxied by the actual or realized variance of the distribution of the stock returns. In this paper we adopt the second approach and compute the physical expectation as the subsequently realized variance.

There are two main approaches in the literature to estimating the common component of the international variance risk premium. Adopting the first approach, Bollerslev et al. (2014) compute the aggregate variance risk premia as a weighted average of the single markets variance risk premia based on market capitalization. Using the second approach, Londono (2015) extends the Bollerslev et al. (2009) model to a two-country setup in order to cast light on the interaction between the variance risk premium and both domestic and international stock returns. The model is based on the assumption of an asymmetric importance between two countries: there is a country driving uncertainty and another country receiving the shocks from the first one.

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We contribute to the existing literature in at least two respects: first we provide an innovative framework for evaluating the common component of the international variance risk premium (e.g. risk aversion), that does not rely on a restrictive assumption on the importance of any of the countries. For this purpose, we use the Diebold-Yilmaz (2012, 2014) methodology which provides, through a generalized variance decomposition of a Vector Autoregressive model, a useful framework to evaluate the connectedness between variance risk premia. More specifically, to the best of our knowledge, this is the first study analyzing not only the aggregate connectedness in variance risk premia (or risk aversion), but also the vulnerability and the contribution of each market to systemic risk aversion. The second contribution is methodological since the Diebold-Yilmaz (2012, 2014) variance decomposition is applied to series (e.g. variance risk premia) which are found to exhibit long memory and structural breaks. The presence of long memory in realized and implied volatility series is well known (see e.g. Andersen and Bollerslev (1997), Bandi and Perron (2006), Barunik and Hlinkova (2016)) and it would require a significant number of lags when using a traditional VAR, which is the model adopted by Diebold-Yilmaz. We prefer to rely on a more parsimonious specification through a Fractionally Integrated VAR (*FIVAR*) model.

Our empirical methodology can be divided into the following stages. First, we investigate the issues of long memory and structural breaks in the variance risk premium series. Given the evidence of long memory contaminated by structural breaks, in any of the series, we adopt an *ARFIMA*(p,d,q) to estimate and make inferences on the fractional integration parameter d in the non-overlapping sub-samples selected according to the endogenous breakpoints.

In the second stage, when turning our focus to multivariate analysis, we employ the fractional integration parameter d obtained in the first stage (which differs across series) to estimate and invert a FIVAR model (using the novel methodology of Do et al. (2013)). In this way we obtain the moving average coefficients necessary to compute the forecast error variance decomposition. This is used to compute both the unconditional (employing the full sample) and the time varying (employing a rolling window) estimate of the total European risk aversion index and the indices of vulnerability and contribution to systemic risk aversion in Europe. Total risk aversion connectedness represents the aggregate (degree of connection among the measures of) risk aversion in the European countries, whereas the indices of vulnerability and contribution to systemic risk aversion represent the total spillover in risk aversion from the system to a specific market (vulnerability), and the total spillover in risk aversion from a specific market to the system (contribution), respectively.

We show that the use of a short memory VAR may underestimate the total connectedness between countries during financial turmoil periods and for forecast horizons equal to thirty days. As a result, by accounting for long memory, we can more accurately assess the total and directional connectedness. In order to monitor financial stability as a whole, regulators and policy-makers should be aware of the high interconnections among European countries and that the use of a short memory VAR when a long memory one is needed may underestimate the total connectedness among countries. Moreover, by closely monitoring the role of each country, policy-makers can better control and influence the direction of risk aversion spillovers across countries. They should take into account that the use of a short memory VAR when a long memory one is needed may underestimate or overestimate the indices of vulnerability and contribution to systemic risk aversion of each country.

The structure of the paper is as follows. Section 2 provides a review of the related literature and identifies the gap in the literature. Section 3 describes the empirical methodology and is divided into three subsections: 3.1 discussing the issues of long memory and structural breaks, 3.2 reporting the estimation of the Fractionally integrated VAR model, and 3.3 presenting the assessment of the risk premia connectedness, based on the Diebold-Yilmaz (2012, 2014) model. Section 4 focuses on the empirical evidence and is divided into two subsections: 4.1 reporting the total connectedness and 4.2 the directional connectedness. The last section concludes.

2. Previous work and literature gap

Our work extends the international variance risk premium literature ((Bollerslev et al. (2014), (Londono (2015)) by proposing to use the Diebold-Yilmaz (2012, 2014) methodology to compute the common component of the international variance risk premium. The advantage of our approach is that it is free from any *a priori* assumption about the relative importance of the countries under investigation. Moreover, we analyze indices of directional connectedness, transmitted and received by each country. Diebold-Yilmaz provides a useful framework to evaluate the common component of stock market index realized volatilities. Based on a generalized variance decomposition of a vector autoregressive model, the Diebold-Yilmaz methodology is applied in Duncan and Kabundi (2013) to investigate the connectedness among South African bonds, commodities, currencies and equities; in Zhang and Wang (2014) to return and volatility spillovers between China and world oil market, in Antonakakis and Badinger (2016) to cast light on the linkages between economic growth and volatility in G7countries, in Liow et al. (in press) to examine stock, securitized real estate, bond, and currency markets and the economic policy uncertainty across seven countries. Unlike previous papers, this is the first one to adapt the Diebold-Yilmaz methodology to investigate the connectedness between risk aversions or variance risk premia.

Given that the series under investigation are affected by long memory, the paper is also related to the literature on multivariate modelling of long memory series. Evidence of long memory in volatility measures is well documented: Baillie et al. (1996), Andersen and Bollerslev (1997), Comte and Renault (1998) provide evidence of long-run dependencies, described by a fractionally integrated process, in GARCH, realized volatiles, and stochastic volatilities models, respectively. More recent empirical studies show that the volatility implied from option prices exhibits properties that are well described by fractionally integrated processes (Bandi and Perron (2006), Christensen and Nielsen (2006)). Evidence of long memory stationarity in the variance risk premium is to be found in studies where there is evidence of fractional co-integration between implied and realized volatilities of an order greater than zero and less than the degree of fractional integration for each volatility series (Bandi and Perron (2006); Christensen and Nielsen (2006); Bollerslev et al. (2013)). Last, Barunik and Hlinkova (2016) re-examine the long-memory dynamics of the implied-realized volatility relationship by means of wavelet regression.

The presence of long memory in realized and implied volatility series would require a large number of lags when using a traditional VAR, which is the model employed by Diebold-Yilmaz (2014). In fact, although the study by Diebold and Yilmaz (2014) focuses on long memory daily realized volatilities (computed using intraday data), the authors still use a stationary VAR adapted to the levels of the series.[1] The use of multivariate long memory models to financial time series has been advocated by Andersen et al. (2001), employing a VAR model to fractionally differenced exchange rates, and by Cassola and Morana (2008) who employ a Vector Autoregressive Model with a common factor following an ARFIMA process to explore co-movements among Euro short-term interest rates. Moreover, Bollerslev et al. (2013) use a co-fractional VAR to model long-run and short-run dynamics of realized variance, implied variance and stock returns in the US market. Barunik and Dvorakova (2015) provide empirical support for the fractional cointegration relationship between daily high and low stock prices, allowing for

[1] To the best of our knowledge, the only study taking into account long memory in daily realized second moments when employing the analytical tools of Diebold and Yilmaz (2009, 2012), is Fengler and Gisler (2015) which is based on the multivariate extension of the heterogeneous autoregressive (HAR) model proposed by Corsi (2009).